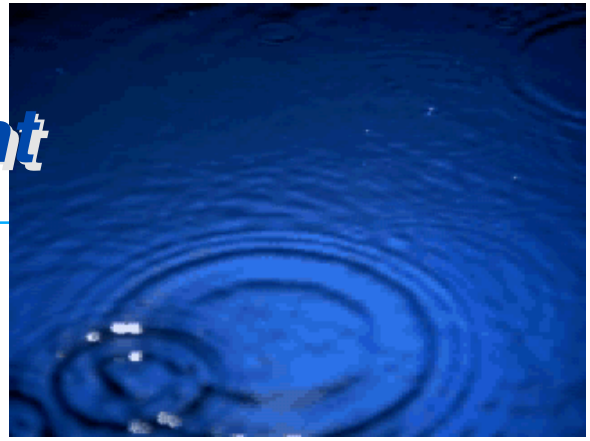
GPM
Global Precipitation Measurement

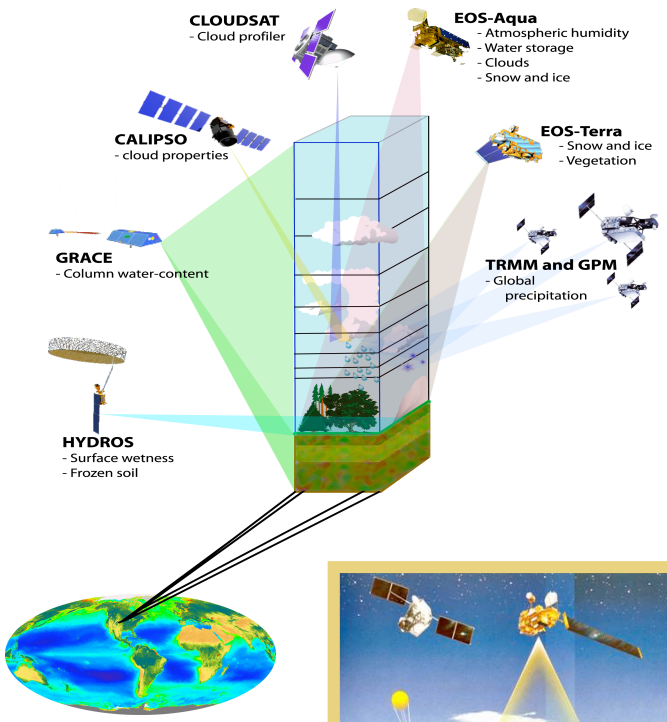
Science Requirements

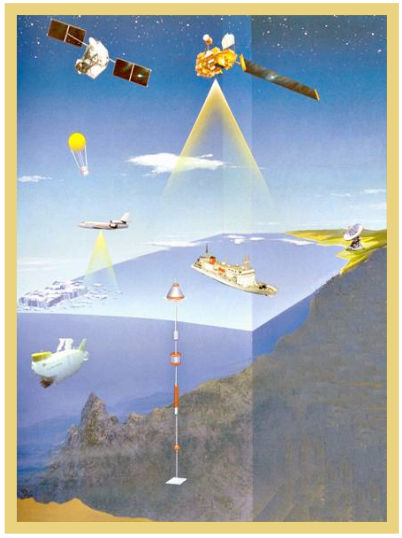


Arthur Y. Hou
Project Scientist
Arthur.y.hou@nasa.gov

System Definition Review
December 6-8, 2005

Global Water and Energy Cycle Observation Strategy





GPM

- ***Flagship mission for NASA's Global Water and Energy Cycle (GWEC) research and applications***
- ***Important contribution to the U.S. Climate Change Science Program & the U.S. Weather Research Program***
- ***Building on***
  - ***the success of TRMM***
  - ***NASA/JAXA capabilities in precipitation measurements from space***
  - ***national and international partnerships in satellite constellation formulation and ground validation***
- ***Prototype for the emerging Global Earth Observing System of Systems (GEOSS), an international effort to provide comprehensive, long-term, and coordinated observations of the Earth***

GPM Science Objectives

- *Advancing precipitation measurement capability from space:*
  - through combined use of active and wide-band passive remote-sensing techniques
- *Advancing understanding of global water/energy cycle variability and fresh water availability:*
  - through better measurement of the space-time variability of global precipitation
- *Improving weather forecasting skills:*
  - through more accurate and frequent measurement of instantaneous rain rates
- *Improving climate modeling & prediction capabilities:*
  - through better understanding of precipitation microphysics, surface water fluxes, soil moisture storage, and atmospheric latent heating distribution
- *Improving prediction capabilities for floods, droughts, fresh water resources, crop conditions, & other water-related applications:*
  - through improved temporal sampling and high-resolution spatial coverage

A science mission with integrated applications goals.
Achieving these science objectives directly leads to societal benefits.

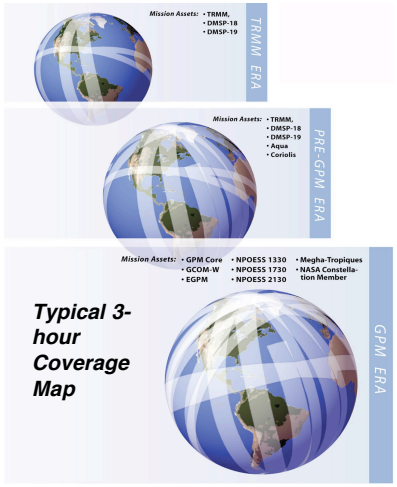
GPM's Dual Role in Global Precipitation Measurement

❖ A Reference Standard for Global Precipitation Measurement:

GPM Core Satellite will carry

- a dual-frequency radar &
- a microwave radiometer imager

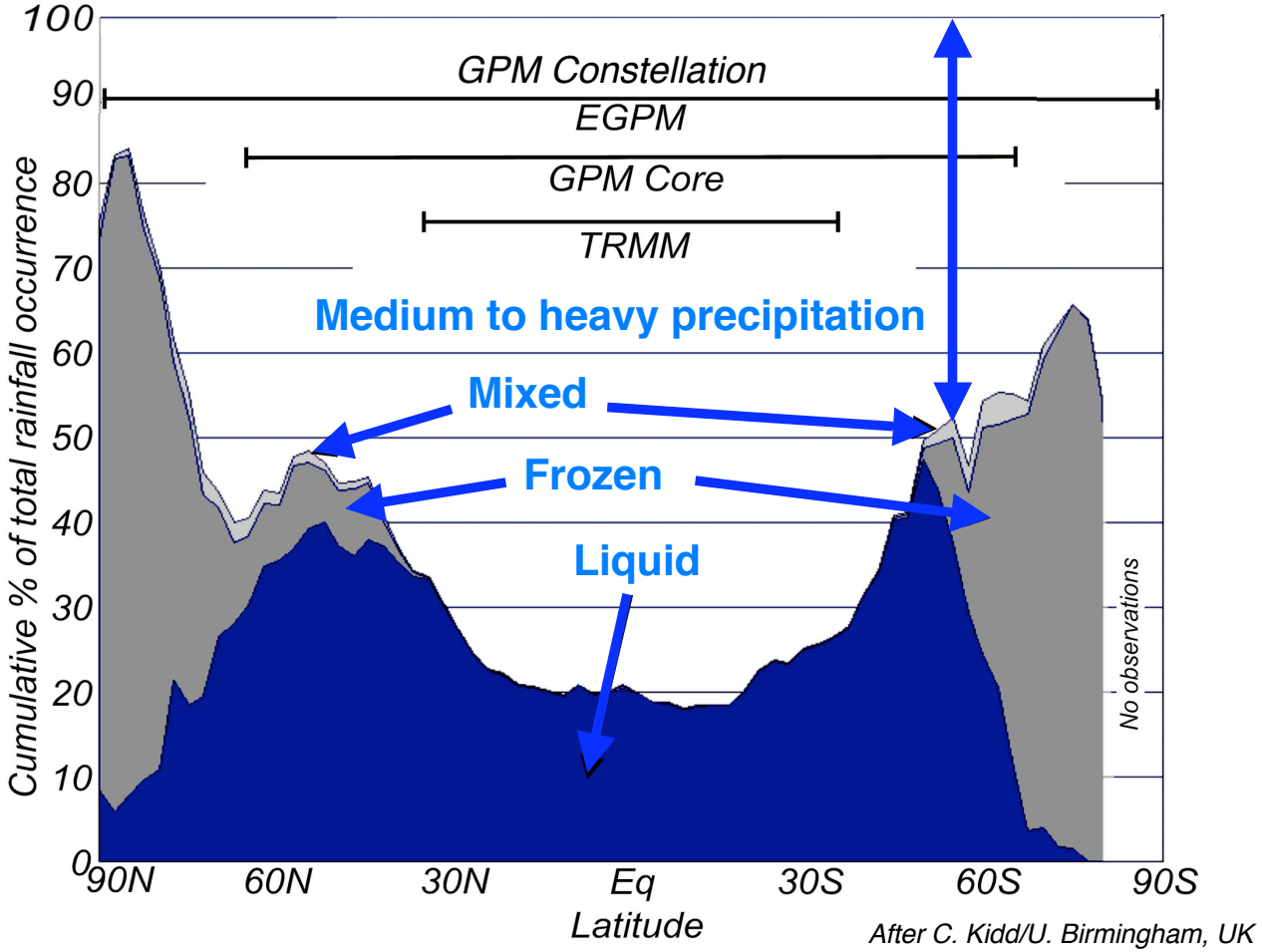
to serve as *a precipitation physics observatory* and *a calibration system* for improving precipitation measurements provided by a heterogeneous constellation of dedicated and operational radiometers.



❖ Optimization of Global Sampling:

GPM provides a *"wild card" constellation satellite* to maximize the coverage and sampling by the constellation satellites.

New Challenges: Measuring Light Rain & Snow

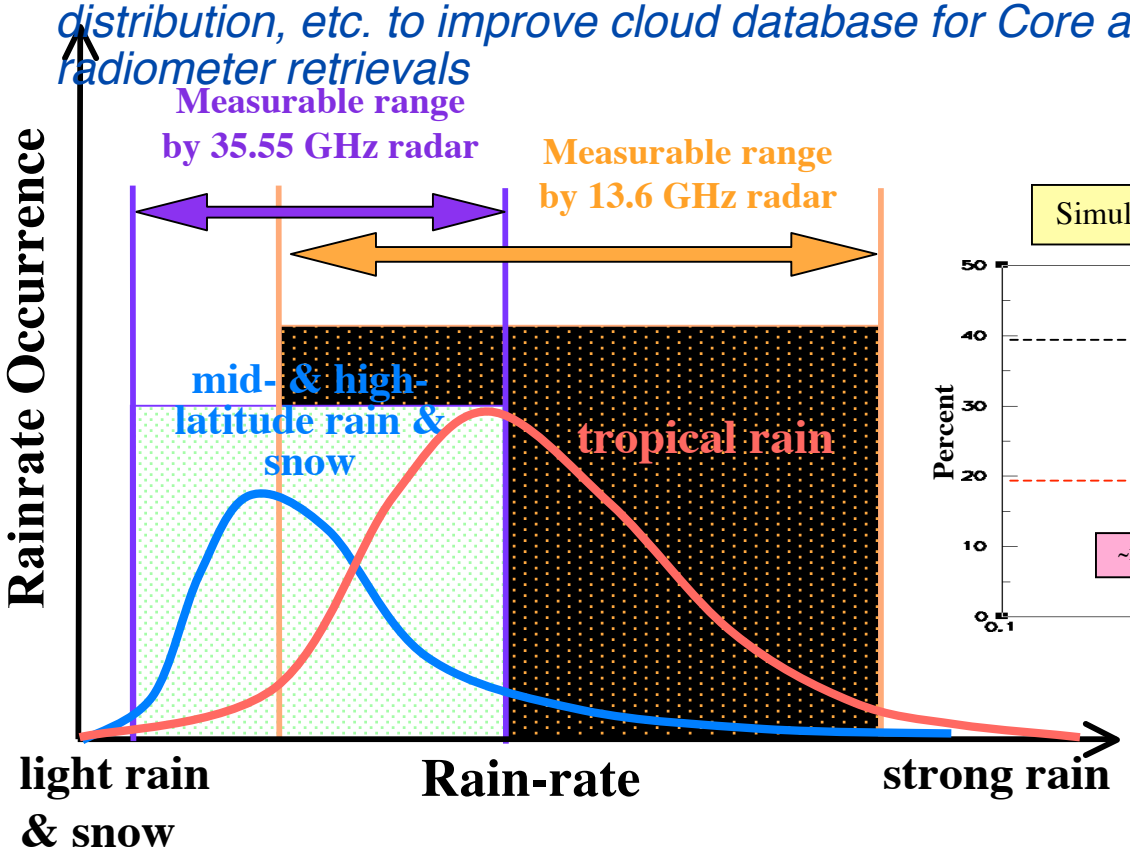


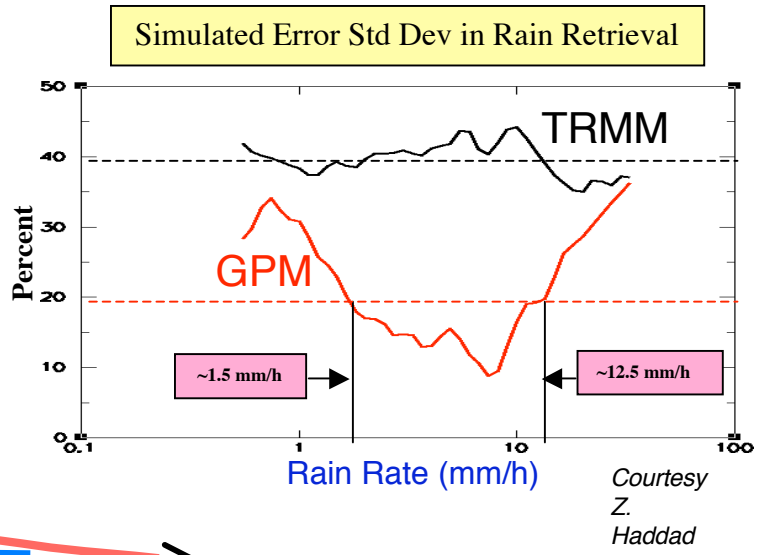
After C. Kidd/U. Birmingham, UK

Detection of light rain (< 0.5 mm/h) and snow requires greater radar sensitivity than TRMM/PR and HF (> 90 GHz) radiometer channels

JAXA/NICT Dual-Frequency Precipitation Radar

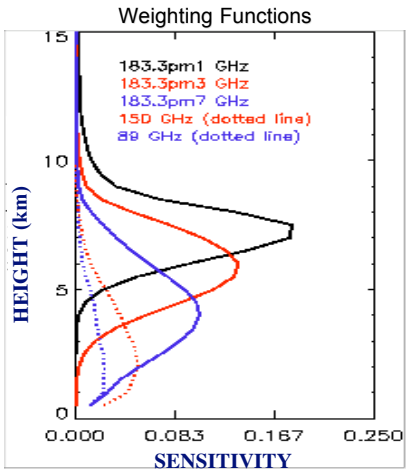
- ***Increased sensitivity for light rain and snow detection*** – *extending the detection threshold from 18 to 11 dBZ (0.5 to 0.17 mm/h)*
- ***Better overall measurement accuracy*** - *replacing the surface reference technique for path-integrated-attenuation correction with dual-frequency methods*
- ***More detailed microphysical information*** – *estimation of drop size distribution, etc. to improve cloud database for Core and constellation radiometer retrievals*



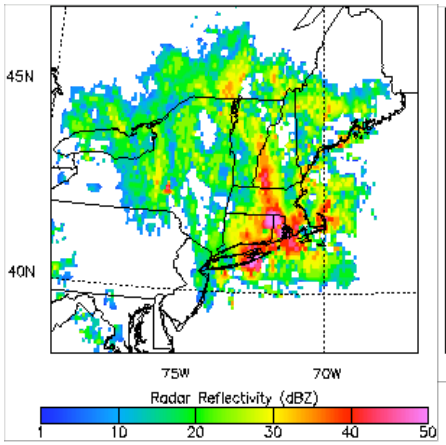


Science values of HF capability on GMI

- ***Measurement of light rain***
- ***Detection of frozen precipitation***
- ***Improved retrieval algorithms over land***
- ***GMI HF channels on Core Spacecraft enabling the testing and evaluation of constellation radiometer algorithms using the DPR***

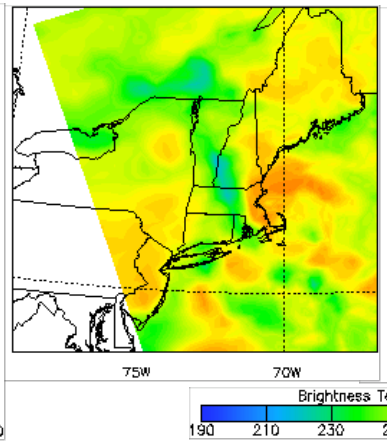


NOAA NEXRAD Data



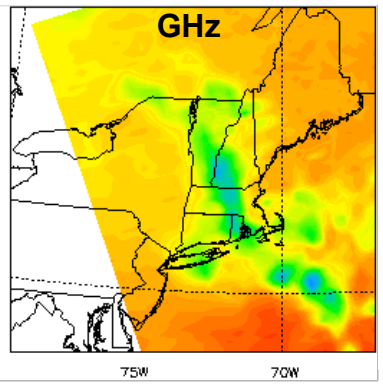
Radar reflectivity composite of the March 5-6, 2001 New England blizzard (75 cm of snow fell on Burlington, VT)

AMSU-B 89 GHz



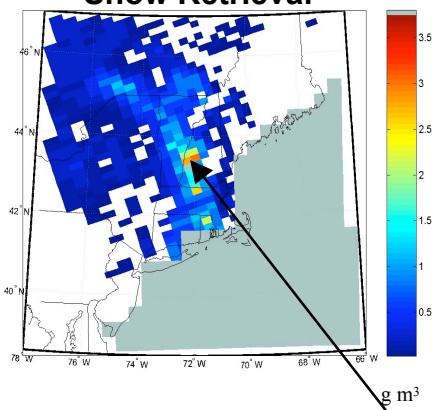
Surface effects evident over the Great Lakes, the St. Lawrence River, and along the Atlantic coast. Cannot distinguish surface from cloud effects.

AMSU-B 183.3 ± 7 GHz



Surface effects screened by water vapor. Snowfall appears over New England as low brightness temperatures

Snow Retrieval



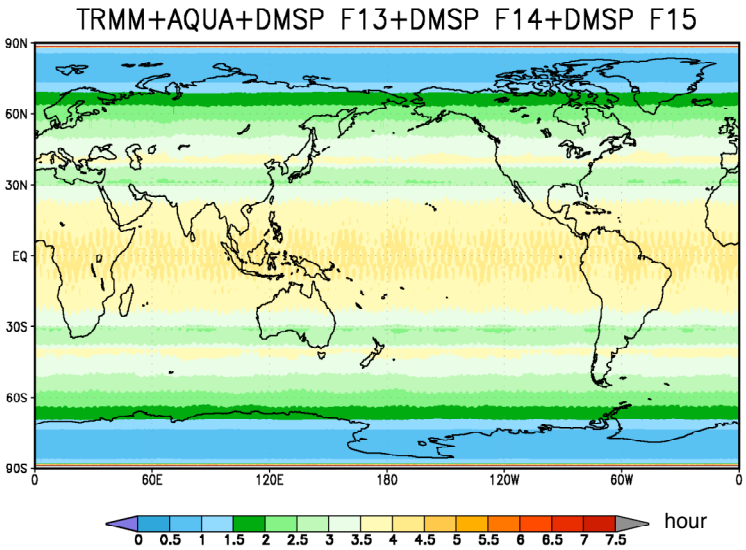
Feasibility demonstration of snowfall retrieval using HF channels

4 in/hr

G. Skofronick-Jackson et al. (GSFC)

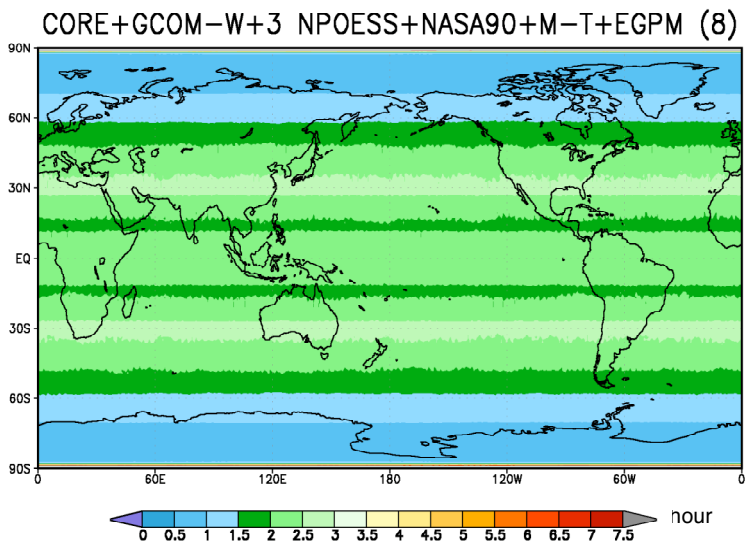
GPM science requirement: 3h revisit time over 80% of globe

Current:
(≤ 3h over 34.6% of globe)



TRMM, Aqua
F13, F14, F15

Expected GPM-Era:
(≤ 3h over 100% of globe)



GPM Core,
3 NPOESS's,
Megha-Tropiques,
GCOM-W
EGPM
NASA-90º

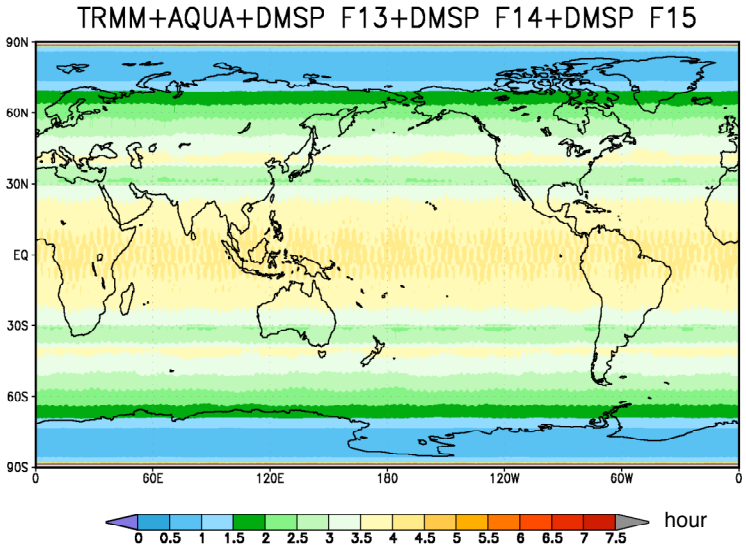
Minimum GPM Science Requirement

Minimum GPM science requirement: 4h revisit time over 80% of globe for at least 18 months of the Core spacecraft mission life

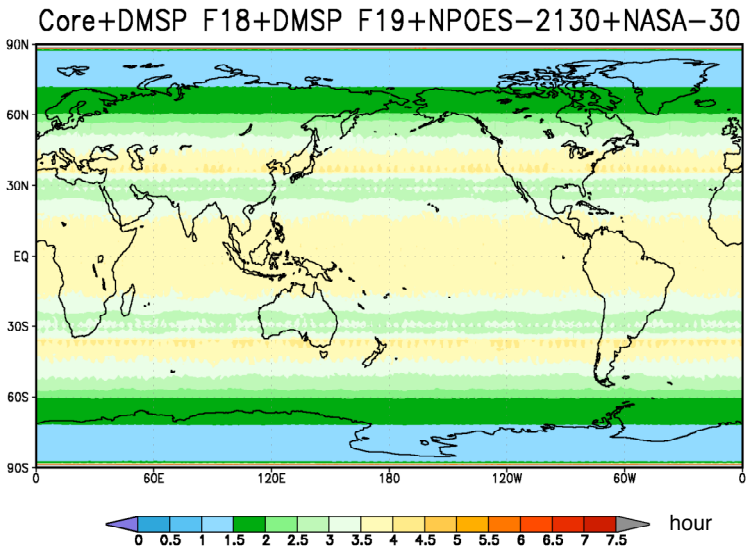
- To obtain DPR-improved MW-radiometer precipitation retrievals with a global coverage equal to or better than the current sampling capability

Current:
(≤ 4h over 91.0% of globe)

Possible Configuration:
(≤ 4h over 98.2% of globe)



TRMM, Aqua, F13, F14, F15



GPM Core, F18, F19, NPEOSS-1, NASA-30º

GPM Measurement Requirements

- ***(3.1.1) Discrimination between convective & stratiform precipitation types***
- ***(3.1.2) Measurement range*** *- 0.3 to 110 mm/h over land and ocean*
- ***(3.1.3) Detection of snowfall***
- ***(3.1.4) Estimation of drop size distribution of precipitating particles***
- ***(3.1.5) Estimation of 3-D latent heat release***
- ***(3.1.6) Horizontal resolution*** *– 5 km between 65^{o}N and 65^{o}S*
- ***(3.1.7) Vertical resolution*** *– 0.25 km between 65^{o}N and 65^{o}S*
- ***(3.1.8) Coverage and Sampling*** *– average revisit time of 3h or less over 80% of the globe*
- ***(3.1.9) Accuracy of instantaneous surface rain rates*** *– biases $\leq$ 10% at 50 km resolution relative to calibrated ground validation data*
- ***(3.1.10) Precision of instantaneous surface rain rates*** *- random errors $\leq$ 25% at 10 mm/h and < 50% at 2 mm/h at 50 km resolution relative to calibrated ground validation data over ocean. Over land, the requirements relaxes by a factor of two.*
- ***(3.1.11) Error characterizations of instantaneous surface rain rates, associated radar reflectivity, and microwave brightness temperatures***

GPM Ground Validation Requirements

- ***Statistical validation sites for direct assessment of GPM satellite surface precipitation products:***
  - *Co-located with existing or upgraded national network (NEXRAD etc.) and dense gauge networks to identify and resolve significant discrepancies between the national network and satellite estimates*
- ***Precipitation process sites for improving understanding and modeling of precipitation physics in physical and radiance spaces for satellite retrieval algorithm improvements:***
  - *Continental tropical, mid- and high-latitude sites (including orographic/coastal sites and targeted sites for resolving discrepancies between satellite algorithms)*
  - *Oceanic tropical and mid-latitude sites*
  - *Aircraft measurements*
- ***Integrated hydrological sites for improving hydrological applications:***
  - *Co-located with existing watersheds maintained by other US agencies and international research programs to use hydrological basins as an integrated measure of the quality of precipitation products*

Sites of different categories can overlap

Data Processing Requirements

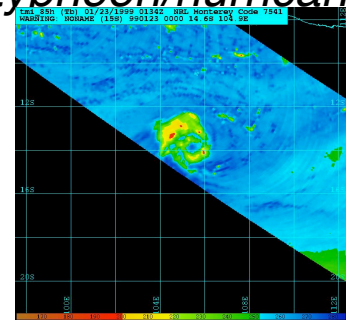
- ***Collection, analysis, distribution, and archiving precipitation data from GPM Core observatory and constellation members to provide standard data products for the GPM and partner science teams:***
  - *Providing orbital swath precipitation data products within 3 hours of observation at 90% of time*
  - *Providing 3-hourly, daily, pentad, and monthly gridded precipitation products*
  - *Providing a hierarchy of precipitation products ordered by retrieval quality:*
    - *(i) Combined core DPR-GMI product, (ii) constellation radiometer product, and (iii) microwave radiometer and sounder (e.g. AMSU, ATMS, etc.) product*
  - *Providing Merged satellite microwave-IR-gauge products*
- ***Providing immediate precipitation products (e.g., 3-hourly rain maps - continuously updated as data arrive) to approved users for outreach activities***

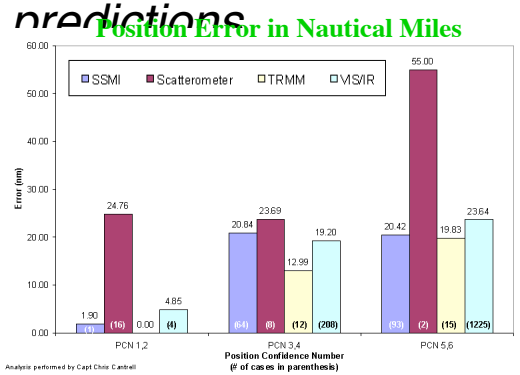
Direct benefits of observations of precipitation intensity and structure

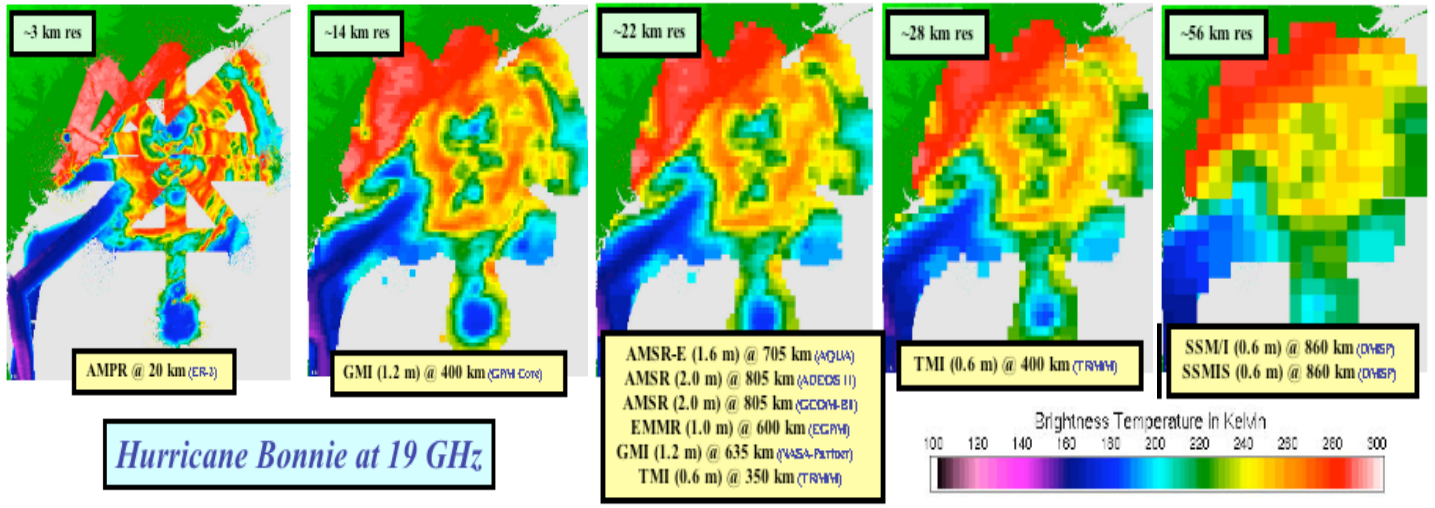
- *Monitoring extreme precipitation events and freshwater availability*
- *Improving position fix for typhoon/hurricane predictions*

Higher-resolution GPM radiometer data can provide better position fixes in early stages of storm development

TMI 85GHz Image of enclosed eye with spiral bands







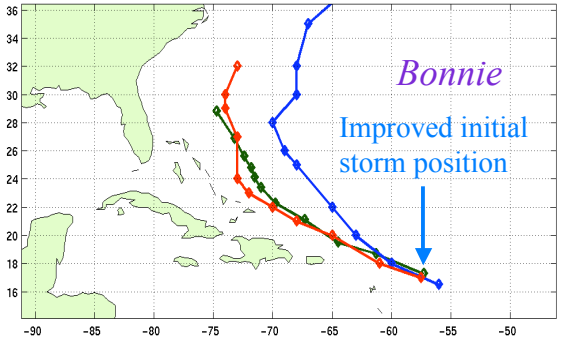
Hurricane Bonnie at 19 GHz

Synthesized Brightness Temperatures (R. Hood NASA/MSFC)

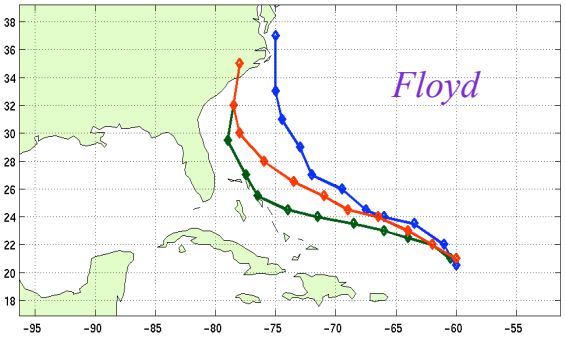
- *Numerical Weather Prediction- Providing swath brightness temperatures and rain rates to operational NWP centers to improve forecast skills*

NASA/GEOS-3 Hurricanes Bonnie and Floyd forecast improvements

5-day track forecast from 12UTC 8/20/98



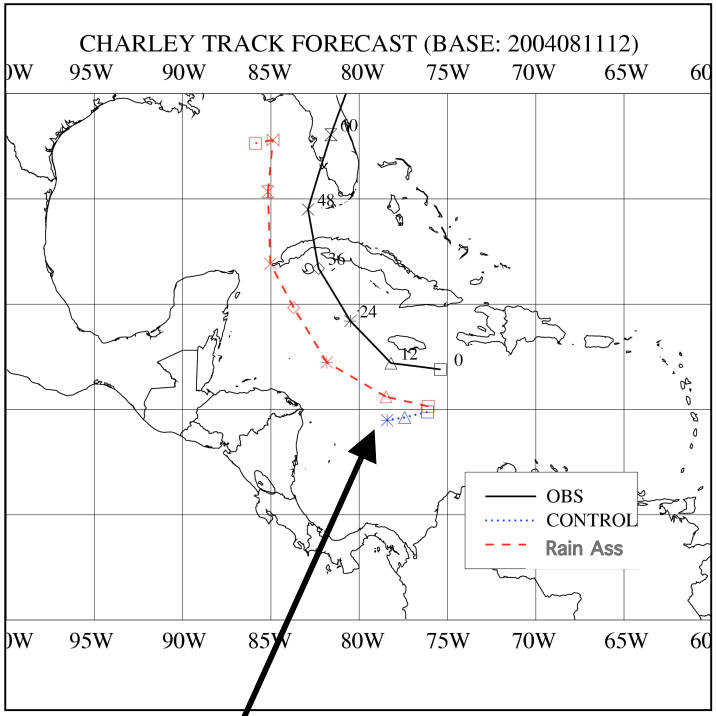
5-day track forecast from 00UTC 9/11/99



Hou et al. (2004)

Green: NOAA "observed track"
Blue: Control forecast without rainfall data
Red: With TMI+SSM/I rainfall data in IC

ECMWF Hurricane Charley track forecasts from analysis 2004081112



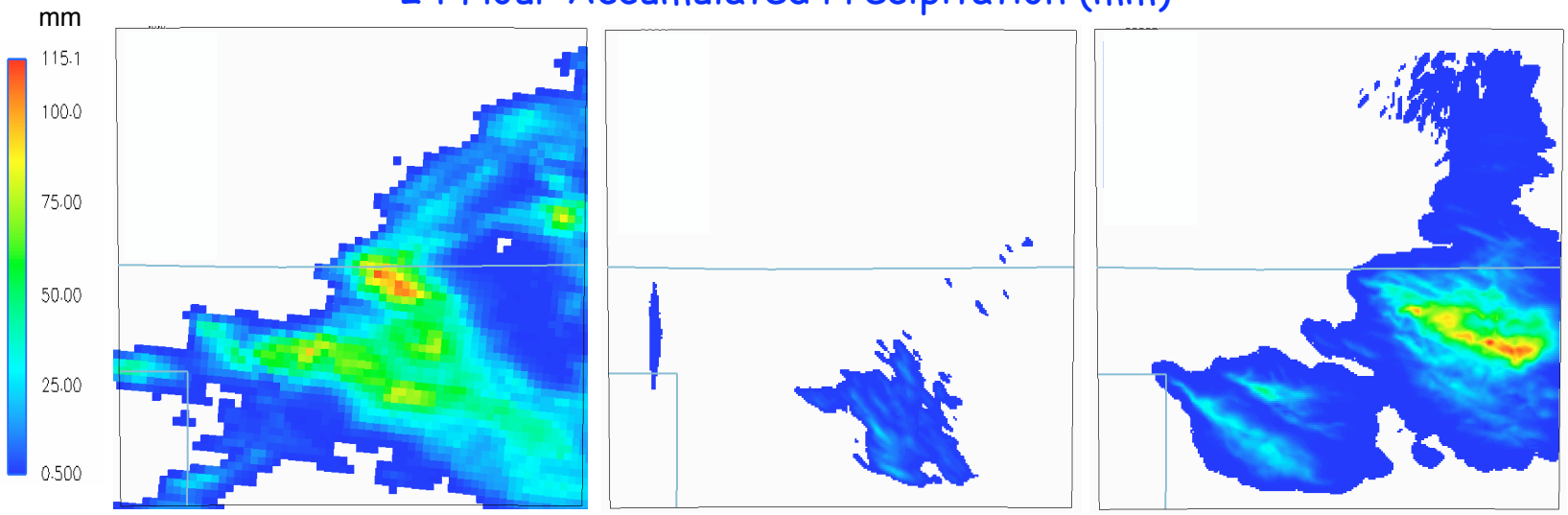
Operational forecast made cyclone disappear!

Courtesy of P. Bauer/ECMWF

- *Hydrological Prediction- Providing 3-hour rainfall products to NOAA to improve operational use of satellite rainfall data in hydrological modeling and prediction*

Impact of improved soil moisture using observed surface rainfall on precipitation forecast, June 12-13, 2002

24 Hour Accumulated Precipitation (mm)



Observed radar + gauge precipitation

Courtesy of C. Peters-Lidard/NASA

Mesoscale (WRF) model forecast using Land-Information-System (LIS) with default soil moisture initialization

WRF-LIS forecast using soil moisture derived from LIS offline spin-up using observed precipitation

GPM Data Applications –IV

- *Applications - Making GPM data products and resources accessible to users and stakeholders beyond the traditional precipitation science community:*
  - *Freshwater Utilization and Resource Management*
  - *Natural Hazard Monitoring/Prediction (Flood Warnings, Hurricane and Cyclone Observation, Winter Weather Events)*
  - *Crop monitoring*
  - *Climate Change Assessment*
  - *Policy and Planning*

- *Outreach - Making immediate precipitation data products available to:*
  - *Students, teachers, and researchers in educational institutions via direct network access to GPM data products*
  - *Commercial and public television enterprises via near-real time graphic rain imagery*
  - *Any government, industrial, and academic users s as well as private homes*

Agenda

Day 1 - December 6, 2005
Location: NASA GSFC B16W-N76/80

Time	Section	Event	Presenter
8:30 AM		Logistics & Announcements	Durning
8:35 AM	1	Introduction	Durning/Ho
8:45 AM		Charge to Review Team/RIDs: Purpose & Review Criteria	Ho
8:55 AM		HQ Overview	Neeck
9:10 AM	2	GPM Mission Overview	Durning
9:55 AM	3	Science Requirements	Hou
10:25 AM		**Break**	
10:40 AM	4	Mission Requirements	Bundas
11:10 AM	5	Mission Architecture	Bundas
11:55 AM		**Lunch**	
12:55 PM	6	Systems Engineering Processes	Bundas
1:40 PM	7	System Safety and Mission Assurance	Toutsi
1:55 PM	8	External Interfaces	Hwang
2:10 PM	9	Dual Precipitation Radar (DPR) Overview/Requirements	Woodall
2:55 PM		**Break**	
3:10 PM	10	GPM Microwave Imager (GMI) Overview/Requirements	Flaming/Bidwell
4:10 PM	11	H-IIA Launch Vehicle	Woodall
4:30 PM		Review Team Caucus	
4:40 PM		**End of Day 1**	